proximately the same illumination as the unrectified 15 watt bulb.

We installed diodes in our traps (it takes about 15 minutes per trap) in the summer of 1984 and had to replace only two bulbs the entire season. The only drawback that we could see to this modification is the possibility of close lightning shorting the diode. In that case, the bulb would burn at full brightness, but would not go out.

A COMPARISON OF THREE TRAPS FOR ADULT *CULICOIDES VARIIPENNIS* (CERATOPOGONIDAE)[1]

F. R. HOLBROOK

Arthropod-borne Animal Diseases Research Laboratory, USDA-ARS, P. O. Box 25327, Denver Federal Center, Denver, CO 80225

Culicoides variipennis (Coquillett) is the only proven vector of bluetongue virus (BTV) throughout most of the United States (Jones and Foster 1978). Field research into the adult behavior of *C. variipennis* is currently being conducted at the Arthropod-borne Animal Diseases Research Laboratory (USDA-ARS), Denver, CO, in support of an effort to develop an integrated system for the management of BTV disease in ruminant livestock. This system will require the development of survey tools designed to provide information on population trends, gonotrophic state, and vector capacity or virus activity.

Methods and trap designs for collecting mosquitoes and other biting flies have been reviewed by Service (1976), and Blanton and Wirth (1979) reviewed those that have been used to collect *Culicoides*. Lillie et al. (1979), during studies on *C. variipennis* in Colorado, used a trap comprised of a funnel and baffles of sheet aluminum with a light source, a power source and a collecting bottle. They reported that a trap with a light source of either two 25 milliamp, 6 volt bulbs or one 40 milliamp, 6 volt bulb and with CO_2 (dry ice) caught about 13 times as many flies as similar traps without dry ice. The following presents results of comparisons of baffle traps with a light source only, and CDC traps with and without dry ice.

The baffle trap designed by Lillie et al. (1979) has been made more durable by substituting galvanized steel for the sheet aluminum; the light source has been increased by using a 50W, 30V bulb operated at 24 volts DC; the rubber strap for holding the collecting jar has been replaced with a screw-top lid affixed at the bottom of the funnel; and the optional trap cover has been made a permanent part of the trap. The CDC traps (Model 512, John W. Hock Co., Gainesville, FL 32604) were operated at 12 volts DC using a CM-47 bulb as a light source with power supplied by gelled-electrolyte rechargeable batteries. The CO_2 source was ca 200 gm dry ice double wrapped in paper and placed above the trap cover in a closed paint can with holes in the bottom to allow the escape of the CO_2.

This study was conducted at 3 sites in the western drainage of the South Platte River northeast of Denver which is in an enzootic area of BTV where *C. variipennis* is commonly collected. Study Site 1, an idle cattle feed lot, was approximately 1.25 km ENE of a small reservoir where *C. variipennis* larvae were commonly collected from gently sloping, muddy banks where cattle had access. Larvae were also occasionally found at the site in a muddy area around a leaking watering tank in one of the pens. Study Site 2 was located 3.5 km ENE of the same reservoir, and larvae were found intermittently around a stock watering tank in a pen. Study Site 3 was located about 9 km SSE of the others, with no larval sites found within a 2.5 km radius. Three traps (one of each type) were used at each site on 3 sides of a building, so that the traps would sample the same population but not compete directly with each other. Trap locations at Site 1 faced west, south and east; at Site 2 west, north and east; and at Site 3 south, east and north. From June 23 to September 15, 1983, traps were operated from sunset to sunrise on 3 nights per period during six 8-day periods. The traps were rotated so that each type was at each position once per 8-day period.

Collections were preserved in 70% ethanol. After initial sorting of male and female *C. variipennis*, female parity (the reproductive status of a fly in relation to whether she has laid eggs) was determined as per Potter and Akey (1978).

The CDC traps without CO_2 caught ca 17 times fewer *C. variipennis* (Table 1) than either of the other 2 trap types. The baffle and CDC traps with CO_2 were almost equal in catches of female flies, but the baffle traps caught nearly 7 times more males and were more effective in catching blood-fed females (Table 2).

The parity of the females caught in the 3 trap types differed (Table 2), although the catches in

[1] This paper reports the results of research only. Mention of a commercial or proprietary product does not constitute a recommendation or an endorsement of this product by the U.S. Department of Agriculture.

Table 1. Comparative catches of *Culicoides variipennis* in 3 trap types (1983).

Period	Dates	Baffle		$CDC+CO_2$		$CDC-CO_2$	
		Female	Male	Female	Male	Female	Male
1	Jun. 23–30	86	10	260	3	2	4
2	Jul. 11–18	81	19	45	0	5	0
3	Jul. 21–28	54	10	14	2	5	2
4	Sep. 1–8	197	16	25	4	15	2
5	Sep. 22–29	60	23	130	4	2	0
6	Oct. 8–15	26	16	59	1	1	0
	Total	504	94	533	14	31	8

Table 2. Parity of female *Culicoides variipennis* caught in baffle (B), $CDC+CO_2$ (CW), and $CDC-CO_2$ (CWO) traps (1983).

Period	Dates	Parity groups and number caught[a]											
		Nulliparous			Parous Empty			Blood-fed			Gravid		
		B	CW	CWO	B	CW	CWO	B	CW	CWO	B	CW	CWO
1	Jun. 23–30	33b	143a	2c	28b	115a	1c	4a	0a	0a	21a	2b	0b
2	Jun. 11–18	21a	33a	1b	8b	11a	2a	1a	1a	0a	51a	0b	2b
3	Jul. 21–28	8a	8a	3a	13a	6ab	1b	1a	0a	0a	32a	0b	1b
4	Sep. 1–8	27a	13b	5b	56a	11ab	5b	3a	0a	0a	111a	1b	5b
5	Sep. 22–29	26b	94a	2c	13b	36a	0c	2a	0a	0a	19a	0b	0b
6	Oct. 8–15	7b	51a	1b	12a	8ab	0b	1a	0a	0a	6a	0a	0a
	Total	122	342	14	130	187	9	12	1	0	240	3	8

a – Numbers with different lower case letters within parity groups within periods are significantly different (0.01% level, Chi square with Yates' Correction).

the CDC trap without CO_2 were so small that any real differences that might be present could not be determined. Nearly all (64% nulliparous and 35% parous empty) of those females caught in the CDC traps with dry ice were presumably engaged in host-seeking, hence the attractiveness of the CO_2. The catches in the baffle traps were about evenly divided between flies engaged in host-seeking (24% nulliparous + 26% parous empty) and those gravid females (48%) searching for an oviposition site and attracted by the bright light. The catches of gravid flies in the baffle traps were statistically higher than in the CDC traps with CO_2 regardless of period, but there were seasonal differences (Table 2) in other categories. The CDC traps with CO_2 caught significantly more host-seeking flies (both nulliparous and parous empty females) early and late in the trapping season, but there was a reversal at mid-season. Whether these differences are reflections of changes in behavior requires further study.

The baffle traps or CDC traps with CO_2 can be used with about equal success as a means of detecting the presence of *C. variipennis*. However, the baffle trap is the better trap if collections are to be made for virus assay, since about 75% of the females collected have taken at least one blood meal from which they may have acquired the virus, as compared to about 35% in the CDC trap with CO_2. The baffle trap would require collections to be made into a fluid such as buffered saline (Walker and Boreham 1976), since there is no fan to prevent their escape from the collecting container.

I express my appreciation to G. V. Richardson, Statistician, USDA-ARS, Fort Collins, CO, for statistical assistance and to R. J. Bobian, Agricultural Research Technician, USDA-ARS, Denver, CO for technical assistance.

References Cited

Blanton, F. S. and W. W. Wirth. 1979. Arthropods of Florida and neighboring land areas. Vol. 10: The sand flies (*Culicoides*) of Florida (Diptera: Ceratopogonidae). Florida Dept. Agric. and Consumer Services. 204 p.

Jones, R. H. and N. M. Foster. 1978. Relevance of laboratory colonies of the vector in arbovirus research—*Culicoides variipennis* and bluetongue. Am. J. Trop. Med. Hyg. 27:168–177.

Lillie, T. H., R. H. Jones, W. C. Marquardt and R. G. Simpson. 1979. A lightweight, portable, and inexpensive baffle trap for collecting *Culicoides variipennis* (Diptera: Ceratopogonidae). Mosq. News 39:675–77.

Potter, H. W. and D. H. Akey. 1978. Pigmentation associated with oogenesis in the biting midge, *Culicoides variipennis:* changes in abdominal tergite patterns. Mosq. News 38:499–504.

Service, M. W. 1976. Mosquito ecology; field sampling methods. John Wiley and Sons, N.Y. 583 p.
Walker, A. R. and P. F. L. Boreham. 1976. Saline as a collecting medium for *Culicoides* (Diptera, Ceratopogonidae) in blood feeding and other studies. Mosq. News 36:18–20.

FACTORS AFFECTING DISTRIBUTION OF *BACILLUS THURINGIENSIS* SEROTYPE H-14 DURING FLOODING OF RICE FIELDS

R. E. McLAUGHLIN[1] AND M. F. VIDRINE[2]

Bacillus thuringiensis serotype H-14 has been recognized as a highly effective mosquito larvicide. Formulations and methods of application have been developed for use in a wide range of habitats against a variety of mosquito species (Lacey 1985). One method of application developed for use in irrigated croplands was the introduction of a diluted suspension of a flowable concentrate formulation at a slow rate over a period of several hours for control of *Psorophora columbiae* (Dyar and Knab). A constant flow rate device (McLaughlin 1983) was placed at the entry point of irrigation water into a rice field. The initial development of concept and testing of operational efficacy were reported earlier (McLaughlin and Vidrine 1984a, 1984b). The optimum amount of formulation to place in 20.8 liter (5.5 gal) containers, the rate of addition at the irrigation water inlet, and a comparison of three flowable concentrate formulations have also been reported (McLaughlin and Vidrine 1984c, 1984d). Development of this system for treatment of entire fields required determination of the major hydrological factors controlling distribution of larvicide. That information was used to establish procedures from timing and placement of containers of larvicide as flooding progressed downfield. The purposes of the note are: 1) identify the major hydrological factors influencing distribution of the larvicide; 2) and establish procedures for treatment of rice fields based upon these factors. The procedures are guidelines and permit flexibility for adjustment to the individuality of each field.

TEST SITE AND DESIGN. Fifteen rice fields in Jefferson Davis Parish, La. were used as they were flooded in the spring of 1982. Three dosages (0.63, 1.89 or 5.67 liters) of a flowable concentrate formulation of *Bacillus thuringiensis* H-14 were diluted in water to 20.8 liters and dispensed via the constant flow device at 80 ml/min. Data were collected on the variables influencing distribution as follows: 1) the number of levee overflows, 2) their relative location in the earthen levees subdividing each field into "pans" or "paddies" that flooded in sequence from the upper to the lower end of the field, 3) the number of these levees in the flooded portion of a field, 4) wind direction and speed during introduction of the material, 5) number of pans flooded initially, 6) numbers of pans flooded 24 hr later, 7) soil moisture at those two times, 8) the rate of water flow at the water entry source (where the material was added to the water at the start of introduction) and, 9) at 24 hr later.

Detailed scale maps (1.0 cm = 50 m) were prepared of each field from US Geological Survey and Agricultural Stabilization and Conservation Service aerial photographs. Field topographic features such as levee contours, overflows in levees, compass direction and areas of each pan were placed on the maps. Areas were determined with dot-chart overlays. Water flow rates at each overflow at the start of the test and 24 hr later were calculated by measurement of width, depth and velocity (corrected by a factor 0.9 of the observed surface velocity). Wind speed was determined with a hand-held anemometer. Soil moisture was graded as dry, moist (forms a crumbly ball when surveyed) or wet (formed a mud ball or water dripped when squeezed).

DETERMINATION OF AREA OF DISTRIBUTION. Larval mosquito populations were inadequate in the field for assays of *B. thuringiensis* H-14 activity *in situ*. Thus, a bioassay system was used to detect location of toxic concentrations of *B. thuringiensis* H-14. This system was reported in the initial description of this method of application (McLaughlin and Vidrine 1984a) and with the results of the data comparing amounts of formulation (McLaughlin and Vidrine 1984c). Water samples were collected at regularly-spaced intervals around the periphery of each pan at the end of the treatment application and again 24 hr after the start of the test. Twenty 3rd or 4th instar larvae of laboratory reared *Aedes aegypti* (Linnaeus) were exposed to each of the water samples (5 larvae each in 4 cups with 20 ml of the field water sampled). No mortality occurred among the checks during the 48 hr observation period. The percentage of larvae killed in each sample

[1] United States Department of Agriculture, Agricultural Research Service, Gulf Coast Mosquito Research, P. O. Box 16923, Lake Charles, LA 70616.
[2] Jefferson Davis Parish Mosquito Abatement District No. 1, Jennings, LA 70546.